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Relative roles of resuspended particles and pore water in release of contaminants from sediment

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Abstract: Sediment layers containing contaminants play a significant role in environmental hydrodynamics. Experiments were conducted in order to characterize the relative roles of resuspended particles and pore water under different flow and sediment conditions. A conservative tracer (NaCl) and a reactive tracer (phosphate) were used as contaminants in the bottom sediment in a laboratory flume. The mixing between the overlying water and pore water occurred over a short time while the desorption of contaminants from fine-grained resuspended particles lasted a relatively long time. The effects of resuspended particles and pore water on the variations of release flux and concentration of contaminants in water with time under different hydrodynamic conditions were quantified. The results show that pore water dominated the initial release flux, which could be several orders of magnitude greater than the flux due to molecular diffusion. Flux contribution of desorption from sediment particles in the latter release could be equal to what was seen from pore water in the initial stage.

Key words: *sediment resuspension; resuspended particle; pore water; release of contaminants; release flux*

1 Introduction

Sediment-water interactions in lakes and rivers have become very important since bottom sediments are large repositories of contaminants (Corbett 2010). When sediment resuspension occurs, the contaminants may not be permanently stored in the bottom sediments and may repeatedly be recycled (Chung et al. 2009). Resuspended particles may be an additional source of solutes if they react in the water column (Fig. 1) (Tengberg et al. 2003). If these particles stay in flowing water, they can be oxidized, releasing dissolved contaminants into the water column (Kalnejais et al. 2007, 2010). The impact of resuspension on water quality depends on both hydrodynamic conditions and sediment features (Li et al. 2002). The sediment's cohesive

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strength depends on multiple factors, including grain size, mineralogical properties, and the activity of benthic organisms, which determine the ability of sediment to resist the shear stress imposed by the overlying water (Dey and Papanicolaou 2008). Contaminants exist in both dissolved and solid phases. The conservative solutes have nothing to do with sediment particles. For reactive solutes, the degree of particle association has to be taken into consideration as chemical reactions can contribute to medium-term or long-term immobilization (Li et al. 2004).

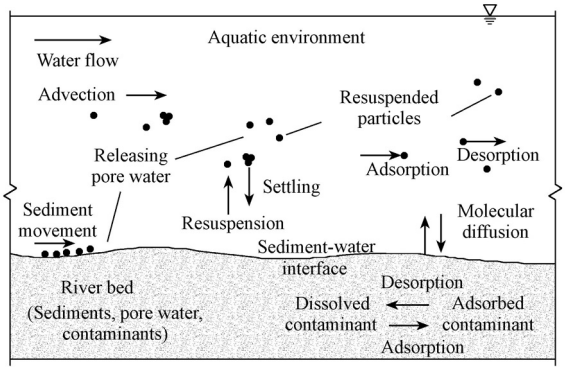

Fig. 1 Mechanisms of interaction between particles and contaminants in conceptual model

The purpose of this study was to investigate the characteristics of conservative and reactive contaminants released from cohesive and non-cohesive sediments over a range of bottom shear stress values. Laboratory experiments were conducted to predict the release flux. This combination of contaminants, sediment properties, and hydrodynamics will enable a more complete understanding of roles of resuspended particles and pore water in the release of pollutants from sediment.

2 Materials and methods

2.1 Experimental apparatus

A circulating flume (Li et al. 2008) consisting of a rectangular test section with 6 m in length, 0.2 m in width, and 0.45 m in depth was used to investigate the response of bottom sediments over a range of flow velocities (Fig. 2). Surface water flow was controlled by a variable frequency pump and a tail valve. The flow velocity varied from 0.1 m/s to 0.3 m/s. The maximum design water depth was 0.4 m.

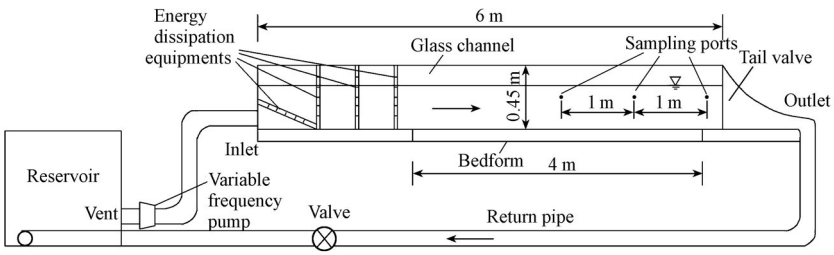

Fig. 2 Schematic diagram of experimental apparatus